

## COATING APPARATUS FOR DISK-SHAPED WORKPIECES

### Cross-reference to Related Application

This is a divisional of application number 09/886,678, filed June 21, 2001, which  
5 claimed priority on Swiss application 1233/00, filed June 22, 2000, which priority claim  
is repeated here.

### Field and Background of the Invention

The present invention builds on the task (1) to reduce in the case of coating installations, for example with virtually continuous 24-hour production operation, the  
10 shutdown times for maintenance, such as, for example, for replacing material sources consumed during the coating process or other installation parts such as coating masks. Therein (2) the coating installation should be constructionally as simple and compact as feasible.

Coating installations conventionally comprise a transport chamber, wherein, in  
15 the simplest case, workpieces are transported from an input/output lock station to a coating station. They are therein coated and subsequently transported back to the input/output lock station. Based on the requirement (2) for the simplest possible concept, a pump unit is provided via a pump opening on the transport chamber, which simultaneously handles the evacuation of the treatment station. Thus, in installations  
20 of this type the transport chamber is also flooded during the flooding of the treatment station. Otherwise the coating station would need to be compartmentalizable with respect to the transport chamber by employing a relatively complicated valve device.

A critical extension of the production shutdown times during the flooding of coating station and transport chamber results therefrom that, together with the transport

chamber, at least portions of the pump unit flanged onto the pump opening are flooded. This leads, for one, to relatively long reconditioning times for the resumption of operation. For another, when, for example, turbovacuum pumps are provided on the pump unit, the latter would have to be compartmentalized against the flooding, which

5 requires complicated and expensive compartmentalization valves.

#### Summary of the Invention

The above cited task (1), namely minimizing shutdown times simultaneously with generating (2) as simple as feasible an installation configuration with high production rate, is realized through an installation according to the claims.

10       Consequently, the coating installation according to the invention comprises a transport chamber with a workpiece transport configuration. The latter has at least two transport rams connected with a rotational axle driven under control, with transport rams, driven under control, which can be linearly extended and retracted. The transport rams are therein in the shell line of one and the same rotation body about the rotational

15 axis and are, with respect to a given direction on the rotational axis, extendable and retractable in the same direction. Each ram bears at the end a workpiece receiver. On the transport chamber are furthermore provided at least two operating openings via which the transport chamber communicates with stations, of which one is a coating station. The surface normals of the clearance areas of said operating openings are

20 therein oriented in the direction of shell lines of the rotation body.

Further provided on the coating installation according to the invention is a pump unit, communicating with the transport chamber via a pump opening, which is effective for the transport chamber as well as also for the coating station.

At least one of said rams has at the end a closure configuration or can be

25 equipped therewith. In order to optimize the simple installation concept which, in all implementations of the coating installation according to the invention, permits extremely

high production rates, also with respect to necessary production interruptions in connection with flooding, while maintaining the simple constructional concept, the pump opening is disposed on the chamber such that said ram can be oriented toward the pump opening, wherein the closure configuration, with orientation of said ram toward 5 the pump opening and subsequently its moving, enters with the pump opening into an operational connection forming a sealed closure.

With respect to the fundamental structure of the transport chamber with said rams, reference is made in particular to EP 0 518 109 corresponding to US Patent 5,245,736 and to DE-GM 29 716 440 corresponding to US Patent 6,416,640.

10 In a first embodiment of the coating installation according to the invention the rotation body is a cylinder or a cone with an angle of aperture  $< 90^\circ$ , and said rams, correspondingly, can be extended and retracted under linear driving parallel or at an obtuse angle with respect to the rotational axis.

15 But in a preferred embodiment the rotation body is a special case of a cone, namely with a  $90^\circ$  aperture angle  $\varphi$ , and the rams project radially from the rotational axis. The operating openings and the pump opening comprise therein surface normals which are in the rotational plane of the rams about the rotational axis.

Consequently, in the last mentioned, preferred embodiment the workpiece 20 transport configuration has at least two transport rams projecting radially from a rotational axle driven under control and linearly extendable and retractable driven under control, which thus are in a plane perpendicular to the rotational axis. Again, at the end on each ram are provided corresponding workpiece receivers. Furthermore, in addition, at least two operating openings, now disposed with the surface normals of the clearance openings in said plane, are provided on the transport chamber, via which the 25 latter communicates with stations, of which, furthermore, one is a workpiece coating station. As in all embodiments of the coating installation according to the invention,

here also a pump unit is provided which, effective for the transport chamber as well as also for the coating station, communicates via a pump opening with the transport chamber.

- As stated, the pump opening is disposed on the transport chamber such that at
- 5 least one of said rams, preferably each, can be oriented toward it. At least one of said rams comprises the closure configuration or can be equipped therewith such that, with the orientation toward the pump opening by being moved, can here also enter with the pump opening into an operational connection forming a sealed closure.

If, in the preferred embodiment of the coating installation according to the

10 invention, and with respect to the rotational axis, the rams are directed radially, the surface normal of the clearance area of the pump opening is consequently also disposed in the rotational plane of said rams.

While it is in principle known from DE 19 742 923 to close the pump opening to

15 one pump unit for flooding a transport chamber, the transport chamber provided on the installation known therefrom, however, comprises as a workpiece transport configuration a solid carrier plate driven about a rotational axis, on whose one plate side, peripheral with respect to the rotational axis, the workpieces are positioned. By axial raising or lowering of the carrier plate, all workpieces, given the corresponding

20 rotational angle orientation, are simultaneously moved toward or moved away with respect to the stations flanged onto the corresponding front face of the transport chamber wall. The plate surface opposing the transport surface of the carrier plate in the case of flooding of the transport chamber, acts onto a pump opening such that it closes it. This pump opening is disposed on the front face, with the front face of the

25 transport chamber opposing the stations. This installation meets none of the requirements according to the task made of the installation according to the invention.

For example it is evident:

- the lifting mechanism for the transport plate must be layed out such that in production it can not only supply the stations with workpieces, but, in the much rarer case, can also be retracted again for the purpose of closing the pump opening: the entire installation must be developed especially for this "rare" case alone.

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Since this additional lift can only be minimized within limits, namely to the extent that the pump effect is not to be choked through the transport plate in production position, this leads to structural enlargement and further complication of the overall installation.

- Relatively complex and expensive measures must be taken to develop the carrier plate, which is locally heat loaded due to the working, such that tight closing of the pump opening can be accomplished at any time and independently of the rotational position.

- The transport plate, which, for the reason stated, must occasionally be at relatively high mass, counteracts high production rates in so far as during the incremental rotation of this plate high inertial moments must be overcome, which requires correspondingly expensive drives for high production rates.

- In a highly preferred embodiment of the coating installation according to the invention only two of the rams are provided which are disposed in said plane offset by  $180^\circ$  with respect to the rotational axis.

- If the rotation body is a cylinder or a cone with an aperture angle less than  $90^\circ$ , said only two rams are disposed in a plane containing said rotational axis. In the case of the preferred embodiment, in which the rotation body is degenerated into a cone with an aperture angle of  $90^\circ$ , said provided two rams are disposed opposite with respect to the rotational axis and, in top view onto the rotational axis, offset by  $180^\circ$ .

consequently also in said plane containing the rotational axis.

In any event, through the two-ram embodiment optimally deep masses to be moved with the transport configuration are realized, and it was found that the minimization of these masses, in view of the acceleration behavior of a rotation

- 5 stepping drive provided for the transport configuration, is significantly more effective than a concept with more than two rams and a corresponding increase of the number of provided coating stations. Through this preferred embodiment, consequently, simultaneously with critical simplification of the installation within the scope of the task of the invention (2), optimization of productivity is attained. This is accomplished
- 10 through the option of realizing the transport between the provided stations through rapid 180° rotational angle steps.

In a highly preferred manner therein are also provided only two of the stations, of which the one is a lock station and the two operating openings - to the lock station and to the coating station - are offset by 180° with respect to the rotational axis of the

- 15 workpiece transport configuration.

If, as in the one of the preferred embodiments of the installation according to the invention, the rotation body is a cylinder or a cone with an aperture angle less than 90°, said operating openings are disposed such that the surface normals of its clearance

openings are aligned with shell lines of said rotation body and specifically with shell lines which oppose one another offset by 180° with respect to the rotational axis, i.e.

- 20 they lie in a plane which contains the rotational axis.

In the especially preferred embodiment of the installation according to the invention, in which the rotation body is degenerated to a cone with an aperture angle of 90°, said operating openings viewed in the direction of the rotational axis and, with

- 25 respect to it, are disposed oppositely with radially directed surface normals.

In a preferred further development of the last cited embodiment, the pump opening between the operating openings and, with respect to them, is disposed preferably offset by 90°.

- Consequently, in the one preferred embodiment of the installation according to
- 5 the invention, in which the rotation body is a cylinder or a cone with an aperture angle less than 90°, the pump opening is again disposed such that its surface normal is aligned with shell lines of the corresponding rotation body, and it is preferably, viewed in the direction of the rotational axis offset by 90° with respect to the operating openings, disposed in-between.

- 10 In the especially preferred embodiment the latter applies identically: in view onto the rotational axis, the surface normals, which are now directed radially, of the operating openings appear to be opposite offset by an angle of 180° with the pump opening offset with respect to it by 90° and disposed in-between.

- Therewith, on the one hand, it is achieved that in production operation the pump  
15 effect is not impaired by the workpiece transport configuration; on the other hand, for the case of flooding through corresponding driving of the rotational drive alone for the workpiece transport configuration, a 90° - instead of 180° - rotational angle step can be initiated in order to bring one of the provided rams into an orientation toward the pump opening. Through the extension and retraction of the rams, provided in any  
20 event also for the production, the pump opening is closed or again released. Consequently, this does not require additional expenditures, since the ram under consideration carries out said pump opening-related lift also during the production with respect to the operating opening.

- It is therein further preferred to dispose a supplemental opening in the wall of the  
25 transport chamber opposite, with respect to the rotational axis, to the pump opening such that in the plane, preferably each offset by 90°, four openings are provided. This

supplemental opening can be employed for a multiplicity of different purposes. It can, for example, together with the closure of the pump opening, if required, also be closed, it can, when not in use, be closed with a cover, and, for example, be employed for service work of every type and/or for measuring workpiece parameters, such as for 5 example for measuring coating distributions and/or coating thicknesses, etc.

Within the scope of as simple as feasible an installation concept (2), it is further preferably proposed that the interior volumes of the coating station and of the transport chamber are connected via a communication connection, not under control, i.e. without a controllable valve configuration being provided in such a connection. Consequently 10 such a connection, as will yet be explained, is an uncontrolled bypass connection.

In a further highly preferred embodiment of the installation according to the invention the coating station provided is a sputter station.

Even though the closure configuration provided at the ends of the rams of the coating installation according to the invention can also be formed by disk-shaped 15 workpieces themselves positioned thereon or by other members especially provided for this purpose, a further simplified concept is attained thereby that the workpiece receivers are formed by workpiece receiving plates, in each instance for at least one disk-shaped workpiece, and that this plate forms the closure configuration. In principle, on the provided workpiece receivers in each instance one disk-shaped, especially 20 preferred circular disk-shaped workpiece, can be applicable so as to be centered with respect to the ram axis, or, grouped about said ram axis two or more disk-shaped workpieces, again clearly preferably circular disk-shaped workpieces.

Although it is further quite possible to provide on the coating installation according to the invention only one or only a portion of the provided ram with the 25 required closure configuration - to orient the particular ram in the case of flooding toward the pump opening - in a highly preferred embodiment on all rams said closure

configuration is provided and this, as stated, preferably also developed as a workpiece carrier plate. But therewith simultaneously the option is given of closing also the operating openings in production operation - as in flooding operation, the pump opening. If a lock station is provided, in this case said closure configuration on the ram 5 oriented to the lock station acts directly as a lock valve and/or on the coating station said closure configuration of the ram, correspondingly oriented toward this station, separates the coating process from the transport chamber.

The installation according to the invention, in particular in its preferred two-ram/two station configuration, is in particular suitable for the fabrication of magnetic or 10 optic storage disks, preferably optic storage disks, therein in particular for the fabrication of CDs of all types, be these normal factory-recorded CDs, CDRs or CDRWs.

#### Brief Description of the Drawings

In the following the invention will be explained by example in conjunction with 15 figures which depict:

Fig. 1 schematically and simplified, a representation in partially sectioned view onto a coating installation according to the invention in the especially preferred embodiment;

20 Fig. 2 in a representation analogous to Figure 1, a further partially sectioned representation in a direction of view turned by 90° with respect to the representation of Figure 1;

Fig. 3 schematically a coating installation according to the invention in a further preferred embodiment, namely with cylindrical rotation body defined by the rotational motion of the ram; and

Fig. 4 in a representation analogous to Figure 3, a coating installation according to the invention with conical rotation body defined by the ram motion, with a cone aperture angle <90°.

#### **Description of the Preferred Embodiments**

- 5 In Figures 1 and 2, the especially preferred coating installation according to the invention is shown, highly compact and conceptually simple, which leads to extremely short fabrication cycles.

The coating installation 1 according to the invention comprises a transport chamber 3. It is structured substantially rotationally symmetric with respect to an axis

- 10 A. Onto one wall portion 5 of the transport chamber 3, substantially perpendicular to axis A, a controlled transport drive 7 is flanged, preferably a stepping drive. Via an opening 9 in said wall 5 it drives a transport configuration 11 provided in transport chamber 3. On an axle end 13 of drive 7, projecting into the transport chamber 3 are mounted two rams 15 opposing one another with respect to axis A and thus to the  
15 driving rotational axis. With respect to axis A, they are radially projecting in a plane E perpendicular to axis A. Upon its rotational motion  $\omega$  about rotational axis A the rams 15 define a degenerated cone with a cone aperture angle  $\varphi = 90^\circ$ . Rams 15 comprise preferably, and as shown, bellows-encapsulated linear drives, by means of which each of the rams can be extended radially with respect to axis A or be retracted,  
20 independently of one another, as indicated by the double arrows F. If, with respect to the linear drives for the rams 15, independent drives are discussed, it means that they can be driven in any desired dependency from one another, thus also, for example, and preferably, synchronously.

- At their ends, the rams 15 carry one workpiece receiving plate 17 each, whose  
25 plate surfaces 17f are perpendicular to the ram axes  $A_s$ .

In the wall of transport chamber 3 are disposed two operating openings. Onto

the one,  $19_B$ , a sputter station 21 is flanged. On the other,  $19_S$  a lock station 23 is realized.

The two openings  $19_B$  and  $19_S$  oppose one another with their central opening surface normals N on transport chamber 3; they are thus, as is readily evident in Figure 5 2, offset with respect to the axis A by a rotational angle of  $180^\circ$  and with their central normal N, which according to Figure 1 coincides with axis  $A_S$ , are also in plane E. Thus, the two openings  $19_B$  and  $19_S$  can each be served simultaneously by the rams 15, and therewith the particular provided stations 21 and 23, as is readily evident based on the ram position shown in dashed lines of Figure 2.

10 In Figure 1 is shown a target 24 on sputter station 21 schematically in dashed lines. A connection line 25 connects the sputter chamber process volume P with the interior of the transport chamber 3. It is understood that the connection line 25, shown schematically for reasons of clarity, is integrated, for example, into the flange 26 for mounting the sputter station 21 and/or into the wall of transport chamber 3, which is 15 readily possible in particular since said bypass connection is not valve-controlled. Via this line 25 the interior volume of the transport chamber 3 and process volume of sputter station 21 communicate permanently and form, if desired, intentionally a pressure stage.

As is further evident, the workpiece receiving plate 17 acts on the particular ram 20 15 oriented to the lock station 23 as a lock valve facing the transport chamber. The lock station 23, realized essentially within the wall thickness of the transport chamber 3, for circular disk-shaped workpieces, in particular magnetic or optic storage disks, therein in particular optic storage disks, preferably CDs of all types, such as CDRs or CDRWs, 27 is (not shown) evacuated through a separate pump port into the minimized 25 lock volume.

At the side of the atmosphere [pressure] the lock volume of the lock station 23

is closed by a schematically depicted lock valve 29 which is in contact on the outside.

Analogously, the workpiece receiving plate 17 with the correspondingly oriented ram 15 blocks the process volume P of the sputter station 21 with respect to the interior volume of the transport chamber 3, whereby the transport chamber is shielded from the  
5 process chamber.

As is further evident in the Figures, in plane E and (see in particular Figure 2) offset in each instance by 90° with respect to the operating openings 19<sub>S</sub> and 19<sub>B</sub>, on the wall of the transport chamber 3 one pump opening 30 is provided and, in a preferred embodiment of the pump opening 30, opposite with respect to axis A and  
10 furthermore in plane E, a further opening 32, which will be denoted as "service opening".

On pump opening 30 is mounted a pump unit 34 (indicated in dashed lines in Figure 1), preferably comprising a mechanical molecular pump, such as in particular a turbovacuum pump, for example a turbomolecular pump and/or turbomolecular drag  
15 pump. If the service opening 32 is not needed or is only needed after the installation has been flooded, it is, as shown in Figure 2, closed by means of a cover or a blind flange 36. Through this opening service work can be carried out or at this opening 32 measurements can be carried out manually and/or measurement transducers etc. can be installed (not shown).

20 As is in particular evident based on Figure 2, one or both of the openings 30 or 32 can be closed thereby that the rams 15 during the production are not swivelled back and forth between the operating operations 19<sub>B</sub> and 19<sub>S</sub> by, in each instance, 180° rotational angle steps, but rather are moved into an intermediate position, offset by 90° with respect to said "operating positions". If for any reason, but in particular for a  
25 change of the target or the coating masks, the sputter station 21 as the coating station and thus, due to the connection 25, also the transport chamber 3 are to be flooded, the

one of the rams 15 is swivelled into the intermediate rotational position shown in Figure 2, and in particular the pump opening 30 is closed by applying the workpiece receiving plate 17 as a closure configuration. If required, and as also shown in Figure 2, with the second ram 15 the service opening 32 can also be closed.

- 5        Thereby with an optimally simple and compact installation, the extremely compact and simple transport configuration, which is utilized in any event for production operation, with rams 15 is also employed for compartmentalizing the pump unit 34 during flooding.

With such a coating installation according to the invention a production cycle rate  
10 of, for example 2.5 seconds, is attained. This means that every 2.0 seconds a coated workpiece disk is transported out. For example, therein on the sputter station 21 after a production coating of 50,000 workpiece disks, a target change, and after a production coating of, for example 5,000 workpiece disks, a mask change must be carried out. Based thereon follows a necessary installation flooding approximately after three hours  
15 in each instance for a mask change, after 28 operating hours for a target change. The necessary time interval to run a pump unit with turbovacuum pump again up, is at least three minutes. Even though this time interval appears to be short, yet with a three-minute additional operating interruption of an installation without pump compartmentalization in the case of flooding, a roughly two percent productivity  
20 reduction results, which, given the above listed numbers, corresponds to a productivity loss of approximately 250,000 workpieces annually. Added to this is the shortening of the service life of the sensitive mechanical molecular pump, which is of particular importance. With the installation according to the invention, said additional operation interruption interval is no longer necessary and the pump reaches the best possible  
25 service life since it does not need to be run up and down again.

In Figure 3 is shown schematically a further embodiment of the coating installation according to the invention. Its structure is readily comprehensible by a

person skilled in the art based on the explanations offered so far. For functionally identical parts the

same reference symbols are used, such as have already been employed in connection with the explanations in connection with Figures 1 and 2.

- 5        The two rams 15 are disposed parallel to the rotational axis A, in contrast to the especially preferred embodiment according to Figures 1 and 2. They consequently define a cylinder during their rotational motion  $\omega$  about axis A. Preferably again two rams are provided disposed oppositely by  $180^\circ$  with respect to axis A, which rams act onto the stations 21 and 23 shown schematically. The center opening normals N of the  
10      clearance areas of the openings connecting the transport chamber 3 with stations 21 or 23, are oriented to the shell lines of the cylinder defined by the ram rotational motion. The pump opening 30 for pump unit 34 and the, if appropriate, provided service opening 32 (not shown) are disposed offset by  $90^\circ$  with respect to operating openings to stations 21 or 23 with identically oriented surface normals N.
- 15       According to Figure 4 the two rams define in their rotational motion about the rotational axis A a cone with a cone angle  $\phi$  of less than  $90^\circ$ . Again, the center surface normals N of the clearance area of the operating openings to stations 21 - preferably a sputter station - and 23 - preferably a lock station - are oriented such that they are aligned with generating or shell lines of the cone defined by the rams 15 during their  
20      rotational motion. The same applies to the schematically shown pump opening 30, provided according to the invention, on which, for reasons of clarity, a pump port 31 is shown schematically in Figure 4.

25       Here too, viewed in the direction of rotational axis A, the operating openings to stations 21 or 23 are preferably disposed offset by  $180^\circ$ , while the pump opening 30 and the possibly provided service opening (not shown) are disposed again offset by  $90^\circ$

with respect to the operating openings.

Consequently, with the installation according to the invention, on the one hand, an extremely high production rate is achieved, due to the simple installation developed only with small moving masses, on which the productivity is additionally optimized  
5 thereby that production shutdown times are significantly reduced. Due to the pump compartmentalization forming an essential part of the present invention, shutdown times for maintenance, such as for example and in particular target change and/or mask change, are minimized and reduced to those times which are, in practice, actually necessary for maintenance. Reconditioning times or time for running up the pump unit  
10 again become unnecessary.